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Journal of the Society of Arts.

FRIDAY, SEPTEMBER 14, 1855.

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MANUFACTURING PROGRESS IN GREAT BRITAIN.

By Lady Bentham.

The paucity of data relative to the manufacturing progress of Great Britain emboldens me to venture to lay before the Society of Arts a trifling contribution towards supplying the deficiency. This attempt commences in the year 1791, and continues to that of 1813, and although the information be very limited, yet, as it relates to many particulars important to the manufacturing prosperity of the country, as also to the well-being of operatives, it may be hoped that the facts stated will not be devoid of interest; they are taken from official documents, and from notes made at the times they relate to.* As the measures introduced by Brigadier-General Sir Samuel Bentham originated in himself, it may not be deemed irrelevant to premise that he having a decided predilection for naval concerns, was taken from Westminster school at the age of 14, to be apprenticed to a master shipwright in a royal dockyard, afterwards studied in all of the several royal arsenals, and on board of Keppel's fleet, travelled for further information in Europe and Asia, and, soon after his return home in 1791, was prevailed upon by Earl Spencer to re-engage himself in the civil service of the navy.

Sir Samuel Bentham has thus officially recorded, that in the year 1791:—"Steam engines were extensively employed for giving motion to pumps, for raising water from mines, to machinery for working cotton, to mills for rolling, and for some other works in metal, but in regard to the working in wood, steam engines had not been applied to this purpose, as no machinery or engines other than turning lathes, so far as I learnt, had as yet been introduced for the working this material, excepting that some circular and reciprocating saws and boring tools had been applied to the purpose of block-making." This induced him to complete some inventions that he had commenced in Russia, and led to his patents of 1791 and 1793,† and to his construction of several machines of full size for working wood, ivory, stone, &c. These machines, while at actual work, were inspected by several of his Majesty's ministers, and were noticed in the House of Commons, where Mr. Secretary Dundas (afterwards Lord Viscount Melville) in particular bestowed great encomiums on them. The specifications of those patents include most of the operations and means of performing them which have since been introduced in the manufactories of the materials specified.

The Naval Administration, having perceived the savings to be derived from the use of such machinery, had by degrees sanctioned the introduction in the dockyards of several of the various machines from the General's private residence in Queen-square-place.

When, in the year 1802, their Lordships had in view the establishment of an improved ropery in the royal dockyards, as also machinery for working metals, Sir Samuel, feeling satisfied that manufacturing establishments could only be carried on with profit by the introduction of the same kind of management as was essential to the prosperity of such concerns in private hands, verbally submitted his ideas to the Earl of St. Vincent, then First Lord of the Admiralty, and stated the advantages derivable from inquiries on the spot as to the management of private manufacturing concerns. His lordship, persuaded that observations and investigations of this nature could best be accomplished by the individual inquiries of the Inspector-General, informed him that on making an official proposal to the Secretary of the Admiralty, permission would be given him (the Inspector General) to make a journey to the north of England; accordingly, on the 1st January, 1803, he proposed to proceed to Sunderland, to examine certain manufactories for making cordage. This proposal was sanctioned the same day.

Though the journey was thus ostensibly confined to cordage and to ironworks, the Inspector-General was known to have it in contemplation, and with the concurrence of the First Lord, to inquire into many subjects of manufacturing interest. Amongst the most important of these, the following may be enumerated:—The mode of management in factories; the manner of keeping accounts; the rate of pay of operatives; the number of hours they may be employed without injury to health and longevity; the age at which children can be useful in a manufactory; the degree of heat and mode of ventilation most conducive to health in workrooms; the effect of night-work in a sanitary point of view, and in that of personal comfort and happiness of the operative; the effect of furnishing operatives with certain commodities by their employer.

The Inspector-General had the advantage of numbering amongst his friends the Messrs. Strutt, of Derby, and as he was well acquainted with their enlightened views, with the sound principles on which their prosperous manufactories were conducted, of the accuracy with which their accounts were kept, and of their extensive acquaintance, he determined first to visit Derby, and as he had fixed upon Mr. Brunel as his agent to carry out his (the Inspector-General's) projected improved management in dockyard manufactories, that gentleman was taken with him as far as Derby, there introduced to the Messrs. Strutt, who permitted him to acquaint himself with the details of their management, and he had during the journey been instructed in the particulars Bentham was desirous of introducing at Portsmouth. At Derby the General was joined by the mechanist in his office.

The firm of the Strutts, of Derby, afforded a striking example of the advantages derivable from *individual responsibility*, a principle which the Inspector-General was so desirous of introducing in the civil branch of the Naval Department. There were three Strutts, brothers; one of them, Joseph, had the charge of the commercial and mercantile branches of business; Mr. George Strutt undertook the care of the manufacturing concerns at Belper; William Strutt was the engineer, inventor, contriver of all improvements in management, no less than of machinery and the structure to contain it. We were the guests of Mr. William Strutt, and thus Bentham was enabled to profit of every moment that he passed during his two visits to Derby.

The mode of management of the Messrs. Strutt was, as above said, that of individual responsibility; so in all the private manufactories subsequently visited, it was found that the masters of them stood alone, for where a partnership existed, it was one partner only that managed the concern, the others being what is termed *sleeping* partners. The nearest approximation to *joint* management was at the Messrs. Grimshaw's ropery, at Bishops Wearmouth, near Sunderland,—in that instance brothers were engaged in the business of the firm, but, in point of fact, the elder brother was sole manager, the other acting under his direction.

The accounts of work-people at the manufactories at Belper were kept according to prescribed simple forms; the amount of wages was made out weekly, and the particulars of them written on a pay-ticket, to be put into the hands of each operative a day before payment. This regulation was introduced for the purpose of enabling each operative to look over the pay-ticket leisurely; if he found or suspected errors in it, time was thus afforded for correction or explanation; in all cases explanation was readily afforded the evening before that of payment, thus delays and alteration at the pay-table were avoided. The accuracy of these pay-notes was, however, rarely even doubted, although they included deductions for lost time, and the cost of coals and milk supplied, and in many cases rent.

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* Having been permitted to accompany my husband on his tour in 1803, the duty of taking notes was confided to me.

† Statement of Services, p. 131. Repertory, vols. 5 and 10.

The rate of pay of operatives was, of course, widely different in the various factories visited. In one factory, employing about 3,000 operatives, most of them were paid according to the work they had done. In the potteries, not any one was suffered to receive higher remuneration (even for skilled services, pattern-designers included) than two guineas a week, for it had been found that when more was paid, the surplus sum led only to dissipation. At Warrington the chief manufacture was sail-cloth for the navy, and operatives were paid by the piece for weaving; their great earnings in the course of two, three, or four days in the week were found to have a bad result to both masters and men, for the weavers, instead of working the whole week, resorted to the public-house as soon as they had earned enough to pay their score, looms were in consequence left useless for half or more of the week; the master weaver was thereby obliged to sink an unnecessary capital in looms; an extra shilling was in consequence offered for each piece beyond a given number the weaver should weave in a week—a notice of this promise was affixed to each loom in one of the greatest factories. The general result of inquiry on the head of pay was that moderate earnings most conduced to the well-being of the operative; that piece-work enabled men of extraordinary skill or industry to earn the compensation his deserts entitled him to. In some factories apprentices were competent to the greater part of the work, as, for instance, at Mr. Bage's flax mills, at Shrewsbury, and which afforded an example of the advantages of good treatment of them. His apprentices were girls, about and above 14 years old, and the management of them was remarkable. During working hours they of course were under the direction of the overlookers of the factory, at other times of that of a mistress. These girls, without exception, exhibited the appearance of robust health, even exceeding that of any description of operatives seen in the course of this tour. Their business was spreading out flax upon a table; they had just time to do this in a quick walk before the machinery carried away the flax, and on returning to operate on a fresh quantity, they had almost to run, thus traversing many miles during every day; yet they were substantially and abundantly fed at the low sum of 6d. per day on the average, provisions being then at war prices. The Inspector-General could not credit this assertion, the account books were, therefore, produced, and on a careful examination of them he found the average not to exceed that sum. In the evening, these girls had schooling and clerical instruction; they were well lodged, clean in person and dress. Some parish girls at day work in the same factory exhibited a melancholy contrast to the apprentices, the parish fed and clothed children being squalid in countenance and general appearance, dirty and slatternly in dress.

The number of hours during which operatives may work without detriment to health or longevity was anxiously inquired into. The Inspector-General's investigations convinced him that for long continuance and for the average of operatives, whether men or women, 10 hours of actual work in the day is as much as is desirable, though most work-people can for a short time well endure 12 hours of active labour, especially if of a healthy kind, and in the open air or well-ventilated places. It is true that some constitutions admit with impunity of even more hours' employment for a long continuance, and that on a spirt, and with mental excitement as a stimulus, a man can exert himself for a much longer time.

As to the age at which children can be usefully employed in manufactories, it appeared that in several factories children of eight to ten years old were as efficient for some purposes as at a greater age, but it also was evident that at this early age relays of such children would be desirable, for, besides schooling, a child of tender years needs variety of occupation. Much, however, seemed to depend on the *home* of the child; at Belper wholesome habitations were provided for the working classes, and many comforts were brought within the parents' means, so that the youngest children in the mills were healthy-looking. At Sheffield it was far otherwise, for most of the children exhibited symptoms of disease, consequent on poor diet and slothful habits.

The degree of heat most conducive to health in work rooms was specially inquired into. Mr. W. Strutt had bestowed much attention on the subject, and his opinion, confirmed by experience in his factories, was that under about 60° Fahr., the fingers of operatives were so benumbed as to injure their work in quantity and quality, whereas on much elevating the heat the operatives suffered in health. The justness of this opinion appeared to be confirmed on subsequent investigation. A remarkable instance of the detriment of much heated rooms to health, was witnessed in the great establishment of Mr. Lee, at Manchester. In this factory the heat was kept up to at least 70 degrees, as the most favourable for spinning cotton, especially of the finer descriptions of yarn, but the sallow complexions of the women and children denoted the insalubrity of the great heat of the work-rooms. As a general observation, it resulted that less mischief to operatives results from working in a temperature rather too low than where it is elevated much above 60° of Fahrenheit.

MODE OF VENTILATION.—At the period in question, full half a century ago, little attention was in general given to the due ventilation of manufactories, though in some few instances it was attended to, as, for example, in the cotton mills at Belper. Mr. W. Strutt had succeeded in accomplishing this desirable purpose, combined with an economical apparatus for warming his factories. He had found that air much heated became little fit for healthy respiration; his heating apparatus was therefore so contrived as to warm a very large quantity of air *moderately*, so as not to burn matters floating in the atmosphere. The air in this furnace was supplied from the exterior of the building, consequently was free from contamination; it was carried into the several rooms by a pipe of large diameter, but the quantity admitted to each room was determined by a self-acting regulator, the valve of which opened or closed according to the heat of the room. In addition to this means of supplying heated air, the windows admitted cold air when needful, by simply inclining inwards one or more panes of glass, in a manner that has since become frequent. A similar arrangement of windows had been some years previously introduced by Dr. G. Fordyce, in St. Thomas's Hospital, who also, by changing the direction of the louvre boards in Brodie's stove manufactory, had succeeded in preventing the recurrence of frequent chest disorders amongst the workmen.

THE EFFECT OF NIGHT WORK IN INFLUENCING THE HEALTH AND COMFORT OF OPERATIVES.—An important subject for investigation. It appeared in several factories where this was practised, that the health of the night set was materially injured, the comfort and happiness of families still more grievously destroyed. The night set of operatives seemed never to enjoy the same degree of robust health as those who only worked by day, but as no statistical account was then attempted of the longevity and freedom from disease of any description of persons under any circumstances, this opinion could be grounded on nothing better than appearances, nor does it seem that even the late census affords data respecting the effects of night work. That the comfort of families was destroyed there could be no doubt, seeing that, it might be, half the members of it were called to the factory at the time that the other moiety ceased their labours; hence meal times could not be the same for all, nor those of sleep and rest or social intercourse. On the other hand, it was evident that goods could be furnished at much lower cost, supposing the buildings and machinery subservient to their production were available by night as well as day, thus spreading the interest of capital sunk over a double quantity of work performed by its means.

THE EFFECTS OF FURNISHING TO OPERATIVES CERTAIN COMMODITIES BY THEIR EMPLOYER.—The truck system seemed no less injurious to the master than to the employed; too frequently the proprietors of works charged a profit upon the articles so sold; and even where no such concealed gains were obtained, they were uniformly suspected of being so. On the other hand, in manufacturing places there are some articles not to be procured of good quality by the labouring classes at a moderate price. At Belper the Messrs. Strutt supplied their work-people with certain articles at wholesale cost price, with such a small addition as would pay the expense of distribution. Coals and milk and lodging were these articles, but purchase of them was entirely optional with the operatives. Coals were furnished them at cost price; milk was not then procurable at Belper, therefore the Strutts kept cows solely to supply their people's wants; and as at first there was not sufficient accommodation at Belper for the three thousand operatives employed by the Strutts, those gentlemen erected suitable buildings, and let them to their own people at rents which barely compensated for the money sunk. It was a pleasurable sight, that long line of buildings, and broad paved terrace, extending its own length, and infant children basking in the sun upon it.

The observations made on this extensive tour were during its course communicated to the Earl of St. Vincent; the officially announced object of it resulted in a determination of the then Board of Admiralty to erect a manufactory of cordage and sail cloth at Woolwich, and the First and other Lords of the Admiralty became still more strongly convinced that the manufacturing business of the naval department could only be carried on with success and economy by assimilating its management to that of prosperous private manufactories. The Inspector-General was encouraged to introduce the working of machinery by common labourers instead of by skilled workmen, and to manage for the present in his own way, the infant establishments of the since called Wood Mills, Metal Mills, and the Millwright's Shop, all in Portsmouth Dockyard. He continued to do so till on the 10th February, 1805, he officially proposed "the institution of three new distinct establishments, namely, of Millwrights, Wood Mills for working in wood, and Metal Mills for working in metal" (Services, p. 141). He at the same time proposed that three new masters should be engaged, for these establishments respectively, also work-people of different descriptions, enclosing an estimate of numbers and rates of pay, saying that the three establishments were now brought to a state for putting them under the dockyard authorities. This proposal was referred to the Navy Board, who by their reply, 22nd March, 1805, considered the dockyard officers and themselves as totally unacquainted with the management of such concerns, and that the Comptroller and other members on the Committee then on visitation saw no other alternative than that of confiding the whole of these establishments to General Bentham. Their lordships thereupon placed under his sole management and control "the superintendance," to use the words of the Committee, "of works of so great magnitude, "consequently the responsibility attaching to the performance thereof;" and the dockyard officers were directed to "enter, pay, or discharge according to the Inspector-General's certificate, all persons requisite for the Wood Mills, Metal Mills, or for the erecting or repairs of machinery."

Their lordships, in confiding these powers to General Bentham, "did not deem it requisite to furnish him with any instructions, or to lay him under any injunctions or restrictions relating to the management of these establishments."

The General had stated officially, that, "in addition to my hopes of thus ensuring success in these particular establishments for which I had thus been made responsible, I had also in view from the first the far more important object of making them, as far as circumstances should admit, serve as *standards* and *examples*, exhibiting the efficiency of that kind of management which my investigations had shown to be that best suited to a naval arsenal generally."

It will be seen in the sequel of this communication, that these establishments actually have been the examples that have led to various improvements in conducting the business of such arsenals—of the facility with which such improvements may be introduced—of the economy derivable therefrom, and of the benefits resulting to the operatives themselves.

There were at that time many "customs" of trades—indeed, several still remain—which were fruitful sources of *strikes*, particularly those which limit an increased number of skilled hands to the employment of those only who had served a regular apprenticeship, and limiting the number of apprentices. Thus, amongst millwrights, the customs and privileges of the trade were exceedingly injurious; for instance, that of double pay for work done by night, thus afforded a strong inducement for deferring till night what might as well have been done in the course of the day. Millwrights were also so pertinacious of the privilege of not permitting any other description of work-people to assist them, that they would not even allow a labourer to turn a grindstone for them. But, as the General has said,* "it was only by *gradual* steps, by perseverance, and by a continued attention to all the particulars on which the success of my plan depended, that I could have any hope of doing away the prejudicial customs of millwrights."† By degrees, however, under his management, "none but really efficient workmen were retained at Portsmouth. Instead of coming to work or leaving it at their own pleasure, they attend a regular call; they receive no greater pay per hour for work done by night than by day," and none but workmen particularly skilful are paid at so high a rate of pay as millwrights receive indiscriminately from private masters, as the greater part of those employed at Portsmouth receive inferior rates of pay, according to their respective degrees of skill and dexterity. They there not only allow common labourers to assist them, but have also admitted amongst them, under the sanction of indentures of apprenticeship, good artificers of other analogous trades, some of them able to do the best millwright's work, and to keep pace with a good millwright, though they receive but the pay of carpenters and joiners.‡ Besides savings thus obtained in the millwright's shop, was the *profit* of master millwrights, which was then 1s. 4d. for each bare day on each man's time, amounting at Portsmouth to £4 13s. 4d. per diem, or at least £1,400 per annum.

But the most important advantage derived from this institution was the introduction of a knowledge of the principle of mechanics, for "no well-grounded judgment can be formed respecting the need there may be for improvement in the shape, in the mode of putting together, or in the fastening of any of the component parts of that very complicated machine a ship, without a perfect knowledge of the principles of mechanics; and though seamen as well as shipwrights, in consequence of the variety of mechanical operations which they have to perform, acquire all of them some idea of mechanical causes and effects more or less just, yet, as the study of mechanical science does not necessarily constitute any part of the education of any of the persons who are concerned in the business of a dockyard, it seems "highly advantageous that there should be such a person as a master millwright, were it only for the purpose of assisting the operative officers with his mechanical knowledge."

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* See p. 144, of "Statement of Services."

† Ditto, p. 147.

‡ There were about 70 millwrights employed in the millwright's shop at Portsmouth. "Answer to Comptroller's Objections."

The general advantage derived from this establishment became soon apparent, both in respect to the diffusion of mechanical knowledge, in officers and men, as also in the introduction of particular machines; for example, in the smith's shop, a boring engine, by which more than half the expense is saved of boring holes, and the savings that resulted from making tools by the millwrights amounted to more than 30 per cent.[*]

But however great might have been savings of this nature, they have been far exceeded by those resulting from the mechanical knowledge that has been diffused by this institution of millwrights, since it has led to the appointment of a civil engineer at each of the principal dockyards, a consequent improvement in ships of war themselves, and of all the accommodations subservient to their construction, outfit, and provision of stores.

In regard to the wood mills, they, in fact, originated as early as the year 1795, when the First Lord and other Lords of the Admiralty, on visiting General Bentham's machinery,[†] perceived the economy and various other advantages that would result from its introduction in naval establishments. Their lordships, early in that year, sanctioned verbally the introduction of a part of it at Redbridge, for the construction of experimental vessels; by degrees machines were taken from the General's residence to the dockyards at Portsmouth and Plymouth, where they were employed for various purposes as early as 1797. They were seen at work by the First and other Lords of the Admiralty during their visitation to those dockyards in the summer of 1802, and were honoured by their lordships' approbation, as recorded in their "Minutes of Proceedings," page 45, but, to use Sir Samuel's words,[‡] "the savings effected by it at that time were little, if any. No one had the requisite means or motives to make the most advantageous use of it, the wood working business of the dockyard being divided under different masters, and in a great number of distinct shops." By the year 1802, the quantity of that machinery already at Portsmouth and Plymouth was considerable, and justified the sending to those yards the Mr. Burr who had been trained by Sir Samuel in the use of his machinery. Under Burr's immediate direction some day labourers were trained to the use of these machines, and by means of some small extra allowances given to those labourers, they were encouraged to exert themselves, but still no systematic plan of management was effected until the direction of the new establishment was, as above-mentioned, confided to the Inspector-General, in April, 1805.

Sir Samuel then proceeded[§] to make arrangements such as would admit of bringing together, under the same management, all works in wood that admitted of being advantageously executed by machinery, and of their being classed under a systematic arrangement of "*operations.*" As, for example, he has said, "in regard to the operation of sawing, the sub-division I looked to was, that all work of one description should be brought together, by which means large and strong saws would be kept to work rough timber, slighter ones for lighter work, as for slitting deals; saws, whether circular or reciprocating, for cutting to fixed depths, or for rebating, tongueing and grooving, and cutting tenons; saws for cutting into lengths, as for block-shells, table-tops, legs, &c.; saws for cutting diagonally, as for cutting off the angles of wood already brought into lengths, as for block-shells, and so on in regard to other operations."

"In regard to working hands," the General says, that, "being fully impressed with the beneficial results that have been found to accrue from the division of labour into certain operations, I considered that, with a view to obtain from those employed the best work, and the greatest quantity of work, it was expedient to confine each individual, as far as possible, to some one particular operation;" and gives, in the way of example, the making of a box, in which there are no less than ten very different operations, each of them requiring a different tool.

But the General's views were much more extensive—he had witnessed the mischievous effects of apprenticeship as limiting the number of operatives available in any craft, as, for instance, in that of the shipwright—and had devised means by which their number might be increased;[*] in the wood mills, therefore, from the outset, he determined that no apprenticeship should be required. To facilitate this innovation, the establishment itself he designated the *Wood Mills*, and the work-people employed in it, *wood millers*. This establishment also exhibited the facility with which might be introduced most of the improvements that had been suggested by his tour in 1803, not confining himself to the one-sided view of advantage to the master, but at the same time to the justice and to the humanity due to the workman. Hence, "a fair day's work for a fair day's wage" was established in these mills. For the master's interest it was that a day's work should be for the same number of hours in winter as in summer; but for the workman's sake, that (unless except in cases of extraordinary emergency) the day's work should not exceed ten working hours—never more than twelve even in cases of emergency; for should their services for that time not suffice, *continuous* work at the mills was to be carried on by a *double set* of hands. This innovation was exemplified in the metal mills, and will be noticed in speaking of them. Then, as to the times of payment of the people, the then practice in all the dockyards was, the witholding pay for three months. This he considered to be unjustifiable; he knew it to be a source of great expense to the men, as they had to raise cash at exorbitant interest to supply immediate wants; also, in point of fact, it was costly to Government, in consequence of the clerks employed. It seemed to him expedient, on the part of Government, that a week's pay should be kept in arrear, however; though in regard to new comers the reserved sum might take place gradually.

Another great advantage to the operatives in the three establishments, was that of allowing them to work when convalescent, though not yet strong, that work being such as could be paid for by the piece. By piece-work Government could not be defrauded, as they always have been by keeping on infirm artificers at day pay. Little as the convalescent might earn, that little was added to his resources, and in point of morality, it proved an important boon; it kept the operative from the public-house, and sustained a habit of industry. It would seem that this arrangement is applicable to many private establishments. To the use of every machine in the wood mills, two wood-millers were equally instructed and habituated, hence, no machine was worse worked in the absence of a miller, nor on the occasional stoppage of a machine was any man thrown out of work, as every man had other employ.

Another great innovation in dockyard business was the introducing piece-work, though piece-work by the job, as it was called, had nominally been sanctioned and was practised in the dockyards, but in reality the earnings of operatives were confined to a certain sum per day. The dockyard officers were bound not to suffer a shipwright's earnings to exceed a certain amount per day, dockyard officers were consequently led to falsification in various and most mischievous shapes, especially as the prices fixed on by the Navy Board often far exceeded the value of the work done; for instance, the price of a middling repair to a 34-feet launch was more than for the building of a new boat of the same description. In some yards the shipwrights took advantage of this, and when they had completed work to the amount of the allowed day's pay, refused to strike another stroke. In other yards officers managed to conceal the prices allowed by their superiors.

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[*] "Services." [†] Patented 1791 and 1793. [‡] Statement of Services, page 151. [§] Ditto, page 153.

[*] S. B., Secretary, Admiralty.

Not so in the three establishments, for in them, after care had been taken that an operative "shall have done sufficient work to make his pay for it by the piece amount to a fair day's work, whatever more work he did than that, by *extraordinary* dexterity, or *extraordinary* exertion, however contrary to dockyard usage, he is allowed to receive without limitation." Job work has been abolished, and the benefit to both master and man resulting from the adoption of the example afforded in Portsmouth Mills has been just now exemplified; for, there being need to forward the Baltic fleet with the utmost expedition, the Admiralty, as the most effectual means of attaining this end, gave orders that operatives should be allowed to work without stint, and that every man should be paid for the work he had really done. What has been the consequence? Evidently that this powerful fleet has been prepared for sea service in so short a time as to have far exceeded all former precedent, and to excite the wonder and the admiration of the nation.

As to the amount of savings obtained in the wood mills, those from the saw mills, introduced by Sir Samuel, amounted to several thousands per annum; they were proposed by him 21st December, 1797, as were saws, both reciprocating and circular; some of those in the wood mills were the *identical* machines that had been seen at work, in the year 1794, at his brother's residence; they have, from their first erection at Portsmouth, been in constant use from that time to the present day. Mr. Burr, in his evidence to arbitrators, instituted by the Act of the 52 Geo. III., deposed that nine-tenths of the usual expense was saved by Sir Samuel's machinery for rebating, and the quantity of work done by his machines has always been immense. So early as the year 1812, his saws were doing between nine and ten thousand feet of work per week, including four and five inch plank. The savings of work done by other machinery of Sir Samuel's invention there are now no means of knowing, but as they were, besides rebating and sawing, for cutting dovetails and tenons, also for boring, for cutting mortices, for forming mouldings, &c., the savings cannot but have been immense; for instance, on the making the trifling article of deal tables for the fleet, the savings were ascertained to be upwards of £700 a year.

The credit and the pecuniary advantages derived from machinery in the wood mills, still continues to be ascribed to Sir Isambard Brunel, but a reference to Sir Samuel Bentham's patents of 1791 and 1793, would alone prove that nearly the whole of Brunel's is described in the specifications of those patents, which is confirmed by official documents; the way in which Sir Isambard was employed in the wood mills appears in Sir Samuel's official "Statement of Services.*

But however great may have been the savings in the wood mills, they are insignificant in comparison with the national prosperity that has resulted from their institution. The machinery therein and in the metal mills, visited, as it has been, by multitudes, has given a practical impulse to manufacturers of wood and metal, for when engines were seen actually performing operations that theretofore required great skill, energy was aroused, and the practicability of introducing similar machinery in private works became apparent. There are few operations in the working of wood and metals that had not been described in Bentham's patents of 1791 and 1793, yet it was not till they were seen in practice in the wood and metal mills that they excited general attention.

The difference in the duration of copper sheathing, and the costly mode of freeing old sheathing from dirt and scale, led the Inspector-General to call the attention of the Admiralty to these subjects before the end of the last century, but it was not till the 12th of April, 1800, that he proposed the manufacturing of copper sheathing in the Royal dockyards, and then, principally, with a view to scientific observation of the particulars on which the goodness of that article depends; but, as he says,* "proceeding in my investigations, it appears that the profits derived by the few manufacturers who monopolised it were so great that at my representations the proposed manufacture in Portsmouth dockyard was extended." At the first outset, at his suggestion, a skilled superintendent of works was engaged, as also several skilled operatives at high pay, but by April, 1805, the metal mills had been brought to a state in which they also could be placed under the regular management of the Navy Board. That Board having declined the task, as above mentioned, this establishment was also placed under the Inspector-General's sole management. The contractors for copper sheathing were powerful, and from the first endeavoured to avert the impending cessation of their gains, by representations in the House of Commons, to the Admiralty, as by other means, direct and indirect; but though the General had to combat this powerful opposition, consequent investigations led to a triumphant disclosure of the many advantages derivable from manufacturing such articles on Government account. After the most minute inquiry, it turned out that copper sheathing rolled in the metal mills was in every respect of superior quality to that obtained by contract, and that it was furnished from these mills at a reduction of 200 per cent. on the contract price, so that the savings that arose from sheathing alone amounted, in 1812, to £39,096 4s., and on all the several works executed in these mills to £40,954 12s. 8d.

Accounts exhibiting profits may be so drawn up as to exhibit more or less favourable results. Those which showed the above results were made as if the concern had been that of a private individual, undertaken with a view to profit. The amounts of expenditure and returns were carried on from half-year to half-year, from the first erection of the mills to the end of 1811, and as if from the outset a private proprietor had borrowed capital at the rate of 5 per cent. interest, both for the capital sunk in buildings and machinery, and for current expenses in carrying on the works, so that the debt was increased half-yearly by those current expenses, by the capital sunk as it increased, and by the interest on capital borrowed; a balance was struck at the end of each half-year, and carried forward to the next half-year, so that the debt was shown to have increased half-yearly by the interest and compound interest on money, as also by a further charge of 5 per cent. on buildings and machinery to cover wear and tear and the chance of disuse.

The amount of savings by manufacturing copper sheathing, together with the superiority of that rolled at the metal mills, occasioned all other branches of metal work to be subservient to sheathing, and that although the savings on copper bolts would have far exceeded those on sheathing. Some smaller articles were, however, produced at those mills, the savings on which amounted to above £1000 per annum. Enough of iron was recast to show the economy that would result from re manufacturing it in a naval arsenal. Mixtures of metals here introduced fitted them for purposes heretofore made by hand of copper; as, for example, bolt nails, 8 or 10 inches long, were cast of a mixture so tough as to be driven into both oak and fir, without splitting the wood, though holes had not been bored for their reception; and a contractor for certain articles could not fulfil his engagement without recourse to the metal mills for instruction as to the improved mixture. The bolt nails in question still supersede the use of bolts, &c., in various parts of a ship, especially for laying decks and fastening plank on to the bottom and sides of a vessel.

From the above particulars it appears that those three establishments have served as models for the manufacturing business of a naval arsenal, and by which the business may be carried on with advantage to the operatives employed, and, at the same time, with great saving to the public. The operatives in the three establishments worked whenever possible by the piece, and were paid the full amount of their earnings, however great. A remarkable instance of this occurred in the metal mills, in the week ending 22nd June, 1811. John Newey in that week worked 5¾ days in casting brass, for which his pay amounted to £6 4s. 8¾d., being £1 1s. 6d. per day. This great amount of course caused the circumstance to be particularly inquired into; the result of the investigation was, that Newey having been brought up in an iron foundry had acquired much dexterity in moulding, so that his castings of brass came out unusually clean, and he was also remarkably industrious and steady. The particulars obtained from the master of the metal mills not satisfying Sir Samuel, he went to Portsmouth himself, there found that the rates at which Newey's work was calculated were somewhat less than those allowed by Jellitoe, a great manufacturer at Gosport, and that they would not be considered otherwise than reasonable. Newey was paid the £6 4s. 8¾d. for his five and three-quarter days' work, and with the gratifying knowledge that Government were in fact gainers by this payment, since loss of metal on re-casting was saved by the uniform perfection of Newey's castings, as also the fuel that would have been expended for re-castings. By a note made at the time, it appears that Sir Samuel took measures for the instruction of men in the metal mills to multiply competitors, thereby to avert the need for paying so exorbitantly for similar work. He considered that although extraordinary skill well deserves compensation, yet that in most cases, in addition to the customs of apprenticeships, it is a deficiency of workmen of particular classes that enhances the price of labour. These conjoint causes he laboured to defeat during the whole of the seventeen years he was in the public service; even in the year 1795, when he was authorised to construct experimental vessels at Redbridge, finding that shipwrights could not be spared from the Royal Dockyards, and that others from the Thames, though out of employ, would not engage themselves for less than 12s. per day, he, in addition to lads, engaged good artificers in trades analogous to shipwrights, binding them as apprentices to himself, and engaging to pay them at the rates of remuneration to carpenters and joiners, from which handicrafts they were taken. The practicability of this measure as to shipwrights was subsequently exemplified in Portsmouth Dockyard* without any consequent inconvenience. The millwrights at Portsmouth struck on account of his introducing a similar measure in respect to them, and sent a deputation to his residence to state that by such means men of other callings would soon rival them, and throw them out of employ. Sir Samuel replied that he was far from wishing to discharge them, but being determined to carry his point, all of the present millwrights were at full liberty to quit the yard, and he would *do without them.* But the millwrights soon gave way and returned to work.†

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* Page 126 and sequel to 126 of the published Statement.

* Statement of Services, p. 68.

Among the contrivances of the Inspector-General, that arrangement may be considered of first-rate importance which enabled factory work to be carried on by night without injury to the health of operatives, or to their comfort.‡ This was effected by the simple expedient of making the change of working hands at one or two o'clock in the day, instead of at 6 in the evening. He first induced the Messrs. Grimshaw to try this scheme at their patent ropery. It is true one set worked later at night than usual, the other set came earlier to work in the morning, but both sets had a sufficient portion of the night for sleep. In point of fact, Messrs. Grimshaw's people were delighted with the arrangement, for not only it enabled them to spend part of every day in other than factory work, as tending their own gardens, for instance, but also on alternate weeks to make long excursions, for as the sets were changed weekly, those who quitted work at one o'clock on the Saturday had not to resume it till the afternoon of Monday. The health and domestic comfort of the operatives was thus preserved. Incessant work is of importance in manufactories of every description where buildings and machinery are requisite, for it enables capital sunk upon them to double their products, and consequently diminishes by half the per centage necessarily charged to them in the way of interest upon capital so sunk. In the metal mills at Portsmouth incessant work was carried on by the Inspector-General in this manner, and the saving thereby produced, reckoning only that of interest on capital expended on buildings and machinery, amounted to no less than £5,000 per annum. Sir Samuel stated officially that the making a similar double use of the accommodations in naval arsenals generally, "would be found an expedient which might go far towards obviating the need of any additions to the dockyards." Truly a consideration of importance, seeing the millions that have been sunk in new works, for which the nation is paying interest now, and will continue to pay interest for ever.

By degrees most of the above-mentioned innovations have come to be introduced in the civil establishments of the naval department more or less generally; many of them, it is true, are practices borrowed from private concerns, but others of them, devised by him, are applicable to private manufacturing concerns, such as that of continuous work without injury to operatives; that of doing away apprenticeships and increasing the number of skilled workmen,—since by such means *strikes* and their mischievous effects could not fail to be greatly diminished, if not altogether avoided.

As to the means of keeping accounts in the three establishments under his direction at Portsmouth, he introduced a mode which furnished all useful particulars at little expense. There was no clerk in any of the three establishments; the accounts were kept by the master of each, assisted by a cabin keeper. In the wood-mills, for instance, the cabin-keeper was a lad at the pay of 1s. 2d. per day; the accounts were sent up weekly for Sir Samuel's inspection, and their accuracy was examined into by a clerk in his office. The time of this clerk expended for examination and calculation of the accounts of the wood-mills amounted to no more than £25 per annum. Yet the accounts in these three establishments were detailed as to essential particulars, even to the recording a single pound of iron consumed, and the work of a single hour of each man employed.

September, 1855.

ADVANCEMENT OF SCIENCE.

At the meeting of the British Association for the Advancement of Science, about to be held at Glasgow, the Parliamentary Committee of that body will present their Report on the question—"Whether any measures could be adopted by the Government or Parliament that would improve the position of Science or its Cultivators in this Country."

The Committees, by this report, appear to have received answers to the above question from several eminent men of science, and they divide the subject under the three following heads:—

"1st. How can the knowledge of scientific truths be most conveniently and effectually extended?

"2nd. What inducements should be held out to students to acquire that knowledge; and, after the period of pupilage has expired, to extend it, and turn it to useful account?

"3rd. What arrangements can be made to give to the whole body of competent men of science a due influence over the determination of practical questions, dependent for their correct solution on an accurate knowledge of scientific principles?"

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* Services, p. 14.

† Letter to the Comptroller of the Navy.

‡ Services, p. 15.

"For the purposes of this inquiry," under the first head the Committee report that, "the community may be divided into those who resort to the Universities for education, and those who do not. As to the former, we know of no step that would be more effectual than that which we have already recommended in our Report of last year, viz.,—that a certain amount of knowledge of physical science should be required from every candidate for a degree. The expediency of this course is strongly urged by Professor Phillips and Mr. Grove, in answer to our query, and also by distinguished witnesses, who gave evidence to the University Commissioners. Your President, in his late address at Liverpool, has stated it as an undeniable proposition, 'that those who administer the affairs of the country ought at least to know enough of science to appreciate its value, and to be acquainted with its wants and bearings on the interests of society.'

"Mr. Grove observes, 'that it is melancholy to see the number of Oxford graduates who do not know the elementary principles of a telescope, a barometer, or a steam engine. The contempt of anything manual or mechanical, which Bacon so strongly reproved, still prevails, to a large extent, among the upper classes.'

"It must be remembered, also, that there is scarcely any profession or vocation in life in which some amount of knowledge of physics may not be a desirable or even necessary acquisition. The legislator, statesman, and even legal tribunals, through ignorance of the principles of natural science, become the prey of charlatans; and vast sums of money may be squandered on impracticable, unnecessarily costly, or useless projects. In legal and medical, as well as in the naval and military services, a knowledge of scientific principles is most essential, and should be imparted to all; but this is too wide a field to enter upon here."

Now there can be no doubt, that if science be made an essential condition for obtaining a degree, it will be taught more extensively at schools, and at the University itself.

While the Committee recommend "that physical science should be required from all candidates for a degree," they "admit that a discretion should be left to the University authorities as to the extent to which this desirable change shall be at first carried ito effect, in full confidence that studies so attractive and useful will eventually obtain from all candidates for University degrees that share of attention to which they are so justly entitled."

As to that portion of the population who do not resort to universities for instruction, it is to be hoped that University Reform will diminish the number of this now very numerous class. In the opinion of the Committee, the best mode of imparting to them instruction in science seems to be that suggested by Mr. Grove and others in their replies to the Circular; that is, "that professors, paid, either wholly or in part, by the State, should be appointed to deliver gratuitous, or very cheap lectures, illustrated by philosophical apparatus, to institutions in London and at the principal provincial towns, whose rules of admission and management should have been duly approved; and, when the system has been well organized, it might even be still further extended."

"Such lectures would be successful only in proportion as they were followed by examinations and rewards to diligent hearers, who might thus be induced to extend their studies, and assist in the diffusion of sound knowledge."

On this subject, Professor Phillips, whose skill and experience in imparting oral instruction are so well known and appreciated, has forwarded to the Committee the following remarks. He observes, "that success in teaching depends not merely, nor even mainly, on the ability of the teacher; it is much more the effect of his standing *in the right relation to his audience.* For conversational, *i.e.* tutorial teaching, *one* class of mind, for public teaching of large audiences, *another* is required. Again, a teacher, whether by conversation or lecture, must *lead by short strings.* You cannot explain the precession of equinoxes to a man who does not know what the rotation of the earth means. .... University men should be employed for university work; local men for local work. No man can take away from others the ignorance which he has never felt, or sympathised with."

The professor then proceeds to urge the employment as teachers of persons in the same grade of life as those to be taught.

Sir Charles Lyell contrasts the state of Germany with that of this country in reference to the teaching of physical science. He says, "that in the former country, not only in cities were there are Universities, but almost everywhere, in places where there exists a school of considerable size for boys under the usual university age, there is at least one teacher to be found whose business it is specially to give instruction in natural philosophy and history, and who has charge of a collection of natural objects. Frequently these teachers are so much devoted to some one of the branches in which they give instruction, as to be authors of original papers in scientific periodicals. So far is this from being the case in England, that I have visited large cities where three are richly endowed ecclesiastical establishments, where I have in vain inquired for a single individual who is pursuing any one branch of physical science or natural history. Hence it happens that if the townspeople, assisted by some of the gentry and clergy of the neighbourhood, establish a museum, they cannot obtain any scientific aid towards its arrangement and superintendence."

Sir Charles suggests that laymen should be almost invariably selected to fill those professorships which relate to the departments of science represented in the Association. He suggests, also, that if provincial lectureships should be established, five or six towns should be first selected, which have exhibited their taste for scientific knowledge by the foundation of museums and the appointment of curators, such as York and Bristol. The Government might enter into an arrangement with the latter to double their salaries, so as to secure to them a continuation of the local patronage already afforded them, and prevent the new grant from becoming merely a substitute for it.

Mr. William Tite, M.P., in his reply, observes:—"The practical course to be adopted, and which has, I believe to some extent, been carried out by private efforts, or the tardy intervention of the State, seems to me to consist, for instance, in the formation of schools of mining in such places as Cornwall, &c.; of schools of arts and sciences in such places as Manchester, &c.; of schools of navigation, in Liverpool, &c.; of agriculture, in York, &c. Perhaps in all it might be found advisable to found thirty schools or colleges of this description, with (it may be) on the average six professors in each. I would propose that these professors should only be appointed after a severe examination before a competent Board, the Board *not* named by the Government, but by the Councils of the Universities, and of the different recognised and chartered scientific institutions. They should be paid by a small fixed salary from the State, but principally by the fees from students, the latter being regulated by the examining Board, or by any municipal council which would undertake to defray the fixed charge, or the cost of the buildings and apparatus necessary. The united body of the professors should be entitled to confer honorary degrees, which should in no case convey any description of exclusive priviledge. ....

"An annual vote of between £18,000 and £27,000 would suffice to carry out this system,—surely a very small sum to be devoted by a country like England, to the practical scientific education of the people."

"The only measures," continues Mr. Tite, "I should at present wish to see adopted to connect science with public affairs, would be by attaching eminent men to the various Government Boards."

Sir Charles Lemon, whose experience in these matters is well known, decidedly objects to any plan under which *itinerant* lecturers should be employed.

The Committee consider that the scientific character of the nation suffers from this cause, that our English system offers so little inducement to mathematicians and physicists to pursue their researches. Young men of twenty-one arrive at a marvellous state of proficiency for their age and then entirely abandon the exact sciences for various professions; a foundation is laid upon which a superstructure worthy of the countrymen of Newton might well be reared, and then the work is abandoned; the student must earn his subsistence, and he cannot earn it by geometrical or physical researches."

The Committee are of opinion that much might be done by the Committee of Privy Council and the Department of Science at Marlborough House, under the direction of the Board of Trade, towards diffusing a knowledge of physical science among the pupils of primary and secondary schools.

They are also of opinion, "that means should be adopted for encouraging the foundation of Museums and Public Libraries, accessible to all, in our principal towns; and by degrees all imposts should be abolished which enhance the cost to the public of scientific publications. Donations should also be made to public libraries and educational establishments, of works published at the expense of the nation; such, *e.g.*, as the Geological and Ordnance Surveys."

On the second point, the Committee feel that the measures above described will not alone be sufficient to effect the object in view. Admitting the attractiveness of Natural Science (and it is impossible to over-estimate the pleasure which its study affords to the majority of minds), it cannot be expected that many men will pursue it to any extent, so long as fellowships and other university prizes continue to be almost exclusively bestowed upon their students in other departments of knowledge. In Oxford more particularly, to use Mr. Grove's words, "the ἦθος, which has been eulogised by some, is peculiarly antagonistic to the study of physical science. It is true that by the recent statutes physics are recognised, but they are not made compulsory or necessary............ From what I saw when resident in Oxford, the *genius loci* is so far removed from such studies, that, unless they are made compulsory, or tempting prizes are held out, the minds of young men will not, for an indefinitely long period, be directed into that channel, and thus, though the examination papers will look very well to the public, science will form no integral part of a university education.

Lord Rosse, again, in his last address to the Royal Society, has added his testimony to that of the many eminent men who have deplored in common the neglect of these studies at Oxford. "A man," says he, "having taken a first class *in literis humanioribus*, may be ignorant of physics in the most elementary form, and be incapable of comprehending the first principles of machinery and manufactures, or of forming a just and enlarged conception of the resources of this great country."

And lastly, the Chancellor of Oxford himself has lately advocated the extension of these studies in an eloquent appeal addressed to the University authorities on the occasion of founding the new museum.

That important and instructive public document, the Report of the Oxford University Commissioners, shows how little the rewards now held out to students in mathematics at that university deserve to be denominated "*tempting*;" they are in truth utterly insufficient; and unless the changes about to be introduced, under the auspices of the Parliamentary Commissioners, shall remedy this defect, the Committee fear that the anticipations above expressed by Mr. Grove will only be too well realized.

They are "convinced that the well-being of the nation would be greatly promoted by an extension of scientific knowledge among all classes, and that more encouragement in the shape of reward for successful exertion must be provided before that desirable end can be accomplished."

More numerous prizes ought to be provided at the universities; and other rewards and inducements, both to study and to the prosecution of scientific research, should be held out by the State.

The Committee advert to the inadequate remuneration of Professors, and quote the following suggestion of Sir John Herschel:—"As one of the most directly beneficial steps which can be taken by Government for the advancement of science itself, as well as for the general diffusion of its principles: viz., to increase the number, and materially improve the position, of the Professors of its several branches in all our Universities and public educational establishments; and to erect Local Professorships in the chief provincial towns, independent of any University; and more especially to make better, and indeed handsome, provision, in the way of salary, for the Professors of those more abstract branches, which cannot be rendered popular and attractive and therefore self-remunerating in the way of lectures."

The Committee regret the unsatisfactory manner in which pensions have hitherto been distributed, and quote the views of the late Professor Forbes as follows:—"It might be considered, whether it would not be desirable to found a number of scientific pensions, to be assigned, not for *relief*, but for *reward* of good service, like the good-service pensions in the army. They would often help to free the man of science from drudgery and potwork, and give him the leisure for original research. They would be better rewards than ribands or stars, or other labels, upon the coats of philosophers."

The expediency of resorting to orders, or decorations, or any extension of the present system of bestowing medals as a means of encouragement to the prosecution of physical researches, is doubted, except in certain special circumstances.

Professor Phillips is of opinion that medals should never be bestowed except for work done and published; and that they should never be given for mere mental proficiency; they should be rewards for public service, rather than proofs of *personal merit*.

Professor Faraday, after speaking of the distinctions, both national and foreign, which may even now be earned, writes, "I cannot say that I have not valued such distinctions; on the contrary, I esteem them very highly, but I do not think I have ever worked for, or sought after them."

The late Professor Moll, of Berlin, in his excellent pamphlet on the State of Science in England, has some remarks on the distribution of orders and medals abroad, which are not calculated to enhance the estimation in which they may be held by any one in this country.

The *juxtaposition* of the principal scientific societies in some central locality in the metropolis is discussed as a question which has lately excited great interest among the cultivators of science.

Lord Rosse, in his address to the Royal Society in 1853, observes, "The interests of Science appear to me to be deeply involved in the question of providing a suitable building for the scientific societies..........If a man, naturally gifted, and well-educated, attends scientific meetings, he will feel himself constrained to work, and therefore it is so important for the advancement of knowledge, that able men should be induced to join and attend the different societies; but nothing I think would have greater attractions than a building in a convenient central situation, where the business of Science would be transacted, where there would be access to the best libraries, and where that kind of society most valued by scientific men would always be within reach."

The advantages of this juxtaposition are also shortly set forth in the memorial on this subject presented to Lord Aberdeen, and are considered so obvious that they need not be re-stated at length. Mr. Grove, on this subject, observes, "It should be borne in mind that scientific men have but very limited means of acting on Government; they are politicians in a less degree than any class of her Majesty's subjects; they consist of men belonging to various classes of society, and whose ordinary occupations differ greatly. Most of the great measures of reform or progress which are effected in this country result from a strong pressure of public opinion, urged on by agitation; and as men of science are peculiarly unfitted for this process, Government might not unreasonably be asked to step out of its usual habits, and to lend science a helping hand."

Professor Forbes observes, " Science must have a local habitation, and be something more than a name, ere it can make a permanent impression on the somewhat material mind of John Bull. As a man without a home, or, if houseless, without a club, is a doubtful and suspicious personage in the opinion of English householders, so is science a questionable myth whilst unprovided with a visible habitation. A first step, then, towards securing a due and wholesome reverence for science in the minds of the masses, educated and uneducated, is the congregation of the more important Scientific Societies in a central and convenient public edifice, where they shall be lodged at the cost, and by the authority, of the State. The *prestige* thus accorded to the Societies would soon extend to their members."

The Astronomer Royal, on the other hand, conceives that the advantages of juxtaposition have been overrated; but admits that if the measure, recommended hereafter under the third head, be adopted, the propriety of such a Capitol of Science would be more evident.

Having, however, considered this question in all its bearings, the Committee cannot too strongly express their conviction, " that the juxtaposition of the principal scientific societies would confer a most important benefit on Science; and almost all concur in this opinion."

Of late years, considerable encouragement has been extended to practical Science, and this is praiseworthy, provided that abstract science receive its due measure of support; but the genius of our countrymen is so eminently practical, that there is great fear that the less showy branch may be comparatively neglected. Mr. Grove observes, that in that case, " not only will practical science itself suffer, but the country will lose its position in the scale of nations in all that most exalts them." It would be, in fact, to use a common phrase, a beginning at the wrong end.

The Committee conceive this is a subject on which much misconception prevails, and that the following statement, therefore, may not be deemed wholly uncalled for:—" It is not uncommon to hear, or even to read, remarks in which the practical application of scientific truths is lauded at the expense of Science itself, so that it might be inferred, that those from whom such observations proceed were completely ignorant—1st, of the extent to which the most abstract scientific investigations have often led to the most useful industrial applications; and 2ndly, of the many instances in which observations and experiments, seemingly trivial, and likely to lead to no useful result, have, sometimes after the lapse of years, and after having been submitted to a succession of master minds, been elaborated into discoveries of the greatest importance to the progress of civilization, and which do honour to human nature.

These objectors to pure Science have either forgotten, or never learnt, that, in the words of an eminent writer, " the modern art of navigation is an unforeseen emanation from the purely speculative, and apparently merely curious inquiry, by the mathematicians of Alexandria, into the properties of three curves formed by the intersection of a plane surface and a cone."

The steam-engine itself, so simple in its origin, and yet so fruitful of great results, derived its most important improvements from the abstract investigations, by Dr. Black and others, into the nature of heat;—though it required the genius of a Watt to make them available in practice.

Some curious properties of chemical substances, when acted on by light, were noted, and then arose the art of Photography, the applications of which both to Science and Art are in course of continual extension. Marvellous properties of light, called its "*polarization*," led to the invention of instruments by which submarine rocks may be discovered, to new modes of detecting the nature of chemical liquids, and to improvements in the art of refining beet-root sugar.

Observations of the magnetism of iron, and on the elasticity of steel and relative expansions of metals, were the origin of the compass and chronometer, without which navigation and commerce (and how many countless blessings follow in *their* train !) would now be in almost as rude a state as in the time of the ancients.

The examination of the properties of gases passing through narrow apertures, showed us how to shield the miner from destruction; and other chemical investigations, how to preserve the sheathing of ships from corrosion—an invention which, from unforeseen and remarkable causes, failed at first, but is now successful.

To say nothing of Astrology and Alchemy, the experiments on the leg of a dead frog were the primary source of the electric telegraph, electro-plating, the power of producing submarine explosions, and of blasting rocks with greater facility and safety, and the other invaluable applications of voltaic electricity to the arts.

The labours of our Geologists teach us how to avoid useless expenditure in searching for minerals where none can by possibility be discovered, and where to seek for materials for our buildings.

Those of the Botanist minister to our health; and the Meteorologist will, in addition to the other important applications of his science, soon be enlisted in the service of navigation. Nor is Science less necessary to excellence in the arts of war than in those of peace; the construction and use of arms, fortification, surveys, rapid locomotion, screw steamers, and so forth, all depend on it for their success. Nor is this all; the calamities and failures in war may often be traced to the inefficient means possessed by governments of distinguishing the really scientific man from the ignorant pretender."

Professor Mill, in his Political Economy, writes:—" No limit can be set to the importance, even in a purely productive and material point of view, of mere thought. The labour of the savant, or speculative thinker, is as much a part of production, in the very narrowest sense, as that of the inventor of a practical art; many such inventions having been the direct consequences of theoretic discoveries, and every extension of knowledge of the powers of nature being fruitful of applications to the purposes of outward life."

On this subject Professor Liebig observes, in a letter to Professor Faraday, dated February, 1845, and cited in Lyell's Travels in North America:—" What struck me most in England was the perception that only those works that have a practical tendency awake attention and command respect; while the purely scientific, which possess far greater merit, are almost unknown. And yet the latter are the proper and true source from which the others flow. Practice alone can never lead to the discovery of a truth or a principle. In Germany it is quite the contrary. Here, in the eyes of scientific men, no value, or at least but a trifling one, is placed on the practical results. The enrichment of Science is alone considered worthy of attention. I do not mean to say that this is better; for both nations the *golden medium* would certainly be a real good fortune."

Almost all who have replied to the Committee's circular, or favoured them with suggestions, are opposed to the establishment of Institutes or Academies; nor is there any wish expressed that men of science, as such, should be appointed to high political offices in the State. As assessors, however, or advisers to executive boards, the services of scientific men would be highly valuable; and in foreign countries such services are believed to be much in request.

Promotions in the Church have been occasionally made avowedly on the ground of literary merit; but if such claims be admissible, it would seem that scientific acquirements should not be overlooked in an age in which scepticism has been nourished by mistaken views of physical phenomena.

The inadequacy of the remuneration of men of science filling public offices is remarked upon, and it is suggested that "not only ought the present scientific offices to be placed on a more eligible footing in respect of remuneration, but that there is need for the institution of others answering to that description, which do not now exist."

The Committee remark, "that the Government has already taken very important steps in the right direction, and has supplied very pressing wants by the establishment of the department of Practical Geology, and of the Marine Department of the Board of Trade, and its office for the discussion of nautical and meteorological data. Much yet remains to be done; but these and other acts, having a like tendency, such, in particular, as the £1,000 grant to the Royal Society before referred to, are an earnest that a disposition is not wanting "*to lend to science a helping hand.*"

The Committee point with pleasure to the fact that in regulating the studies of candidates for employment in India, Physical Science was not forgotten by the eminent men whose signatures are appended to the report thereon.

It appears to the Committee "that the question of the propriety of instituting public examinations, by which the degree of proficiency in knowledge of all candidates for public employment might be tested, is one of great interest, and that its right determination must exercise an important influence on the progress of education in any country."

Finally, under both the above general heads may be classed all measures for facilitating the circulation of scientific publications both at home and abroad—an object the importance of which it is difficult to over-estimate.

Under the third head the Committee report that late events have shown that a disposition is not wanting in Government to give additional encouragement to Science.

The committee observe that the Board of Visitors of the Greenwich Observatory has, in the proper discharge of its duties, been often compelled to recommend large outlays upon that establishment, and matters connected with astronomy; and it is believed there is no instance on record of the measures recommended being rejected, or even postponed, whatever might be the condition of public affairs, or whatever party might be in power. This the committee conceive to arise from the confidence reposed in the Astronomer-Royal and Board of Visitors, and instance the late Board of Longitude as another example of a like kind.

These considerations suggested the question, whether some Board could not be organised, somewhat after the model of these Boards, but with improvements, which should distribute Government grants, perform for the whole domain of Science the functions which two of the above-mentioned Boards still discharge for Navigation and Astronomy, and moreover act as a referee and arbitrator in matters connected with science brought under its cognizance by Government. At present, in Science, as in Art, Government has no responsible adviser, and the acceptance or rejection of any proposal of a scientific character, or of one for the proper determination of which some knowledge of science is required, depends upon the fiat of those who preside over the several public departments by virtue of qualifications, high it may be for the general purposes of the State, but wholly inadequate to the proper solution of the particular questions at issue.

Professor Forbes says, "I do not think anything like an Institute desirable, ... but I think that some Board, having at once authority and knowledge, should be constituted for the regulation and disposition of Government grants for scientific purposes, such as the assistance and endowment of scientific expeditions, the publication of their results, &c.; matters at present disposed of by capricious, often extravagant, oftener parsimonious, and sometimes pernicious methods. An approximation towards a right course is already made in the case of the disposal of the £1,000 grant for assisting scientific researches. Now, I would work all Government grants for such purposes as the above-mentioned, by a modification of that scheme, viz., through an unsaleried committee, constituted much as the Recommendation Committee is at present, combined with an *endowed staff*, consisting of a salaried representative (always a man of distinguished eminence and authority in his line of research) of each of the following departments:—

Mathematics.
Astronomy.
Physics.
Mechanics.
Physiology.
Zoology.
Botany.
Geology.
Chemistry."

Colonel Sabine considers that the working of the Board of Longitude, whilst Dr. Young was its secretary, affords a model which, with a few and slight modifications, might be extremely suitable for a Board, which should be constituted with a more extended scientific scope.

Admiral Smyth writes, "Now for Science a real boon would be the establishment of a proper Board of Longitude, organized on clear principles, and armed with power tantamount to its responsibility. This great step gained, the cultivators of science would necessarily advance. .... A good Board of Longitude is meet for a maritime nation, and would, *de facto*, form its great synod of knowledge." Again, he writes, he does not mean a Board constituted as the former one so called, but "a useful institution, resembling the French Bureau des Longitudes, a Board managed by unequivocally qualified men, both in talent and vocation, with regular salaries, who are personally responsible for their public proceedings, whether regarding opinions, rewards, or publications. This Bureau is composed of Géomètres, Astronomes, Anciens Navigateurs, Géographes, Artistes, and Adjoints; and there is no doubt but that the model may be improved."

Sir Philip Egerton describes the evils which result to Science from the want of system in entertaining and deciding upon projects, and carrying out the determinations of successive Governments in reference to questions of science. He complains that applications have to be made sometimes to one department, sometimes to another; that Governments are prone to give ear not to propositions in relation solely to the acquisition and furtherance of pure Science, but to the economic application of scientific principles to the improvement of arts and manufactures; a most essential matter, indeed, and properly confided to the Board of Trade, but which ought not to be confounded with the more intellectual process of scientific research. Sir Philip thus proceeds: "The toil and labour of the latter are too apt to be left to the unaided exertions of the scientific drudge, and the Government steps in and reaps the benefit,—the osprey catches the fish, but the sea-eagle appropriates it. The remedy I would propose for this state of things is, the establishment of a Board of Science, to which all questions of a scientific nature might be referred by the Government for consideration. The constitution of this Board might be easily made such as to command the confidence both of the Government and the public; but it should be provided, that only a portion of the members should be dependent on the existence of the Ministry of the day. Certain funds might be placed yearly at the absolute disposition of the Board; but all recommendations for the application of large funds would of course require the sanction of the Government."

The Astronomer Royal considers a restriction of the functions of the Board desirable; he thinks that it should *initiate* proposals and *urge* them on the Government; but he objects to its acting as a *general* referee and arbitrator in *all* matters connected with science.

There is an expression in the letter of Professor Forbes quoted by the Committee as describing, with great propriety, what ought to be the characteristics of the future Board; he says, "*it should have at once authority and knowledge;*" and after weighing all the above suggestions, and considering the constitution of other Boards established for carrying out nearly similar objects, the Committee think "that the new Board should be composed of a certain number of persons holding high official situations in the State, more or less connected with science and education; and others holding scientific offices under the Government; together with the most eminent men in every department of science. With respect to the official class, there can be no necessity that they should be as numerous as in the late Board of Longitude, of which about fourteen persons answering to that description were members. Lord Rosse, the Astronomer Royal, and Admiral Smyth, have expressed opinions unfavourable to the admission of great Officers of State as *ex-officio* members of the proposed Board. Admiral Smyth is even opposed to *ex-officio* members altogether, and would have all the members of the Board elected." In these views of the Admiral the Committee cannot concur, but the expediency of admitting the great officers at all admits of some doubt.

Whatever determination, however, may be adopted in reference to these matters, the Committee are anxious that a principle of stability and permanence should have place in constituting a body which is to exercise such important functions. A certain proportion of the members might perhaps hold their offices for life, as is now the case in the Board of Visitors at Greenwich; but some provision should be made for the retirement of a sufficient number, to ensure the ranks being recruited occasionally by the election of young and rising men in the various departments of science. It may not perhaps be advisable to endanger the success of an application to Government for the establishment of this Board, by adopting the suggestions of those who desire that salaries should be given to several of its members, as such.

It will be necessary that a secretary, with a salary, should be appointed to the Board, and that a place of meeting and deposit for papers should be assigned.

Professor Phillips suggests that the proceedings of the Board should be embodied in an annual report to Parliament, which should be widely circulated; a suggestion in which we entirely coincide.

It will probably be thought right that the functions of the Board should be rather strictly defined in the instrument which constitutes it.

If the working of the Board be satisfactory, and the confidence of Parliament and the public be really acquired, it is hardly taking too sanguine a view to anticipate,—1st, that there will be greater assistance and encouragement given than heretofore to science, and scientific researches and the reduction and publication of such researches, in cases where such aid is required; 2ndly, that the necessary funds will be more directly and easily obtained; and, 3rdly, that the influence and authority of such a body of distinguished men will ensure the adoption of all suggestions made or approved by them for the benefit of science, check improvident and reckless schemes, promote those that are deserving of encouragement, and generally give to science its due weight and importance in the councils of the nation.

It may be that the union in one Board, of men holding high executive offices in the State, and others who, however distinguished in their own departments of knowledge, have in the course of their pursuits acquired habits of abstraction, which are supposed by some to be unfavourable to the development of administrative capacity, will be attended with beneficial results to the working of the Institution in question, the members of which will learn by degrees to appreciate all that is valuable in the characteristics of each of the sections of which it will be composed.

In the opinion of the Committee, "the new Board ought not to consist of less than about thirty-five members; and, if it be objected that this number is too large for business, it must be borne in mind, that most of the work will be done by standing sub-committees for the various departments of science, organised somewhat after the model of the Sections in the British Association, reporting to the general body, who will revise their proceedings. The late Board of Longitude, though presiding over only one department of science, contained about twenty-seven members.

Lord Rosse is doubtful as to the expediency of constituting the new Board of Science, on the ground, principally, that the duties here assigned to it might equally well be performed by the Council of the Royal Society, enlarged for the purpose; and that the Society would be in fact so far superseded by this new body. In this view the Committee do not concur.

The Government again are never likely, as has been before fully explained, to extend as much of their confidence to any one Society, however eminent, as to the proposed Board.

In conclusion, the Committee have the gratification of discovering that none of the suggestions offered, or changes proposed, are of such a nature as to impose any serious difficulty on Government, Parliament, or the Universities, were they at once to concede all that is asked.

Such of the above suggestions as are deserving of the serious and earnest attention of Government, Parliament, and the Universities, and which we may term the desiderata, the Committee consider may be summed up in the following propositions:—

1st.—That reforms shall take place gradually in the system of any of our Universities which do not at present exact a certain proficiency in physical science as a condition preliminary to obtaining a degree.

2ndly.—That the number of Professors of Physical Science at the Universities shall be increased, where necessary; but that, at all events, by a re-distribution of subjects, or other arrangements, provision should be made for effectually teaching all the various branches of physical science.

3rdly.—That Professors and Local Teachers shall be appointed to give lectures on Science in the chief provincial towns, for whose use philosophical apparatus shall be provided; and that arrangements shall be made for testing by examination the proficiency of those who attend such lectures.

4thly.—That the formation of Museums and Public Libraries in such towns, open to all classes, shall be encouraged and assisted in like manner as aid is now given to instruction in the principles of art; and that all imposts shall by degrees be abolished that impede the diffusion of scientific knowledge; and such donations of national publications be made as above mentioned.

5thly.—That more encouragement shall be given, by fellowships, increased salaries to Professors, and other rewards, to the study of Physical Science.

6thly.—That an alteration shall be made in the present system of bestowing pensions; some annuities in the nature of good-service pensions be granted; and additional aid be given to the prosecution, reduction, and publication of scientific researches.

7thly.—That an appropriate building, in some central situation in London, shall be provided at the cost of the nation, in which the principal Scientific Societies may be located together.

8thly.—That scientific offices shall be placed more nearly on a level, in respect to salary, with such other civil appointments as are an object of ambition to highly-educated men; that the officers themselves shall be emancipated from all such interference as is calculated to obstruct the zealous performance of their duties; and that new scientific offices shall be created in some cases in which they are required.

9thly.—That facilities shall be given for transmitting and receiving scientific publications to and from our colonies and foreign parts.

10thly, and lastly.—That a Board of Science shall be constituted, composed partly of persons holding offices under the Crown, and partly of men of the highest eminence in science, which shall have the control and expenditure of the greater part, at least, of the public funds given for its advancement and encouragement, shall originate applications for pecuniary or other aid to science, and generally perform such functions as are above described, together with such others as Government or Parliament may think fit to impose upon it.

It will be observed, that the majority of the above desiderata may be described rather as suggestions on behalf of national education than as privileges to be conferred on science. Three of the propositions, however, the 6th, 7th, and 8th, involve the establishment of privileges and rewards not now enjoyed by those who make science either their profession or pursuit. Still it must be borne in mind that the encouragement thereby afforded to the cultivation of science, and not the boon to the individual, is the principal object in view.

The 10th proposition, the establishment of the Board, is not advocated as a means of increasing privileges and emoluments, but as the best mode of accomplishing an important national object.

Of the value of Science no one surely can doubt who has received any mental training worthy of the name of education; and, notwithstanding any seeming indifference to an object of such vital importance, we believe that a feeling does pervade the community at large, that our country's welfare, and even safety, depend upon its due encouragement and fostering; and this is evidenced by the readiness with which the House of Commons accedes to demands when made on its behalf. Owing, however, to the system which prevails in this country, of each successive Government striving to outvie its predecessors in popularity by the reduction of public burdens, there is a temptation sometimes to withhold grants which may swell the total outlay of departments in which reductions are contemplated. This it is more particularly which, in the opinion of the Committee, renders the creation of the new Board, or some analogous measure, necessary.

The Committee, in conclusion, state that, whatever may be the result of this appeal, or of any other measures which it may adopt in the discharge of its duty of watching over the interests of Science, it will never cease its endeavours to diffuse a sense of what is due to Science, and to those who make great personal sacrifices for the sake of a pursuit on which the happiness and welfare of mankind so materially depend.

July 14, 1855.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette September 7th*, 1855.]

Dated 10th August, 1855.

1809. A. Heaven, Longsight, Manchester—Machinery for embroidering fabrics.
1811. W. H. Lancaster, and J. Smith, Liverpool—Gas.
1813. J. Betteley, Liverpool—Ships' chain cables.
1815. E. Finch, Chepstow—Loading and unloading coal vessels.
1817. J. L. Stevens, Fish-street-hill—Steam boilers.
1819. P. Lagergren, Stockholm—Paddle wheels.
1821. E. and W. Ullmer, Fetter-lane—Cutting paper and millboards.

Dated 11th August, 1855.

1825. J. Gardner, Plaistow—Salt.
1827. W. Brown, 5, Catherine-street, Lambeth—Sheet metal casks and kegs.
1829. A. C. Morrison, 3, Acacia-place, St. John's-wood—Compound for feeding horses, &c.

Dated 13th August, 1855.

1831. L. Normandy, 67, Judd-street—Circular weaving machine. (A communication.)
1833. W. Hancock, Upper Chadwell-street—Casks, barrels, and linings of same.
1835. E. D. and G. Draper, Massachusetts, U.S.—Can for oiling machinery. (A communication.)
1837. T. Butler, Willenhall, Staffordshire—Locks.

Dated 14th August, 1855.

1839. T. Kempson, Birmingham—Steam engine and boiler.
1841. G. Sanders, Dublin, and R. E. Donovan, Castleknock, Dublin—Gas meters and steam boilers.
1843. M. Mellor, Hyde, Chester—Self-acting mules.
1845. J. C. Haddan, Cannon-row—Cannon.

Dated 16th August, 1855.

1856. J. A. Stocqueller, Regent-street, and W. J. B. Saunders, Southwark—Mechanical means for obtaining elevations.
1858. C. Joyner, Birmingham—Stopcock.
1860. F. Paget, Vienna—Penholder. (A communication.)
1862. J. Atherton and W. Boyes, Preston—Looms.
1864. W. and F. B. Fawcett, Kidderminster—Carpets.
1866. W. Maynes, Stockport—Self-acting temples.

Dated 17th August, 1855.

1868. I. J. Danduran, Paris—Driving apparatus.
1870. D. Brown, Smethwick, and J. Brown, Kingswinford—Bayonets.
1872. T. Edge, Great Peter-street, Westminster—Gas meters.

Dated 18th August, 1855.

1874. W. Sangster, 75, Cheapside—Umbrellas and parasols.
1878. F. Tavernier, Paris—Combing wool, &c.

Dated 20th August, 1855.

1880. A. Dubrulle, Lille (Nord), France—Safety lamps.
1882. F. Journeaux, Mount Shannon Mills, Dublin—Drying grain.
1884. W. Avery, Smethwick—Bands for transmitting power.
1886. P. Goutier, Paris—Treating linseed, poppy, and other oils, &c.

Dated August 21st, 1855.

1888. R. Longsdon, Queen street-place—Removing property into and out of strong rooms, &c.
1892. C. L. A. Meinig, Piccadilly, and F. X. Kukla, Raven-row, Mile-end—Ornamenting surfaces.
1894. L. Paige, Vermont, U.S.—Railway breaks.
1896. J. Wormald and G. Pollard, 2, Bridge-foot, Vauxhall—Ratchet braces.

Dated August 22nd, 1855.

1898. C. V. Bergh, Lacken, Belgium—Packing pistons.
1900. W. Spence, 50, Chancery-lane—Finishing cloth. (A communication.)

Dated August 23rd, 1855.

1904. T. E. Wyche, Camberwell—Propelling vessels.
1906. C. Clauss, Liverpool—Removing hairs from hides and skins.
1908. E. Parod, Paris—Steering vessels.
1910. W. Denton, Addingham, Yorkshire—Drawing wool, &c., off combs.
1912. W. Kidman, Poplar—Tillers or yokes.

Dated August 24th, 1855.

1914. F. S. Archer, Great Russell-street—Photography.
1916. H. Frooms, Manchester—Pianofortes.
1918. T. De la Rue, Bunhill-row—Printing inks.
1920. P. Effertz, Aix-la-Chapelle—Bricks, tiles, pipes, &c.

Dated August 25th, 1855.

1922. J. Avery, 32, Essex-street, Strand—Handles for augers, gimlets, &c. (A communication.)
1924. J. Avery, 32, Essex-street, Strand—Automatic attachments for gates and doors. (A communication.)
1926. W. Brown, Wandsworth—Paper bags.

INVENTION WITH COMPLETE SPECIFICATION FILED.

1969. J. and T. Hope, Rhode Island, U.S.—Machine for engraving the surface of a calico printer's roller, preparatory to its being etched.—31st August, 1855.

WEEKLY LIST OF PATENTS SEALED.

Sealed August 31st, 1855.

489. John Lewis, Elizabethtown, U.S.—Improvements in rigging and sparring vessels.
504. Joseph Cooper, Birmingham—Certain improvements in joiners' braces, and in the mode of forming or partially forming the various bits to be used with such or any other kind of brace.
519. John Taylor, Spring-grove, Isleworth—Improvement in packing and preserving eggs and other articles of food.
520. Henry Gilbert, Kensington—Improvements in hurdles.
552. John Gilbert, Boston-street, Hackney—Improved pump or pumping apparatus.
588. George Grignon, 13, Sutherland-square, Walworth—Improvements in the means of launching or detaching boats from ships' sides or davits, and in the apparatus and tackle to be used for that purpose, that the operation may be speedy, spontaneous, and safe.
630. Alfred Vincent Newton, 66, Chancery-lane—Improved machinery for forming moulds for casting.
636. Matthew Semple, Plymouth—Improvements in railway breaks.
646. William Young, Queen-street, Cheapside—Improvements in stoves or fire places.
689. George Hall Nicoll, Dundee, N.B.—Improvements in laundry stoves.
698. James Porritt, Stubbins Vale Mills, near Ramsbottom—Improvements in steam engines.
1016. Johnson Hands, Epsom—Improvements in boiler, and other furnaces and flues.
1081. John Dupre, Plymouth—Improvements in the construction of ovens.
1203. John Avery, 32, Essex-street, Strand—Improvements in apparatus for conveying heavy weights for bridge building and other purposes.